

A COMPARISON OF THE EFFECTS OF ERRORFUL AND ERRORLESS TEACHING  
METHODS ON THE ACQUISITION, GENERALIZATION, AND RETENTION OF  
LETTER SOUND DISCRIMINATIONS IN YOUNG CHILDREN

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The present study compared the effects of an errorless stimulus shaping procedure to an errorful fluency based procedure for teaching difficult letter sound discriminations using a counterbalanced multielement experimental design. For 2 participants, letters fsteai were taught using the errorless procedure and letters bpdvou were taught using the errorful procedure. For the other 2 participants the conditions were reversed. All participants had considerably fewer errors and fewer trials to criterion with the errorless than with the errorful procedure. Tests of retention and generalization indicate that the errorful procedure generalized and was retained at a higher frequency than the errorless procedure. For 3 participants preference for the errorless procedure over the errorful procedure was demonstrated; whereas, the fourth participant demonstrated preference for the errorful procedure.

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## CHAPTER 1

### INTRODUCTION

Learning to read requires a visual discrimination of the letters of the alphabet where each letter must function as a discriminative stimulus that controls or sets the occasion for a response (Bradley-Johnson, Sunderman, & Johnson, 1983; Browder, Koury, Belfiore, Heller, Wozniak, Lallie, & Chien-Hui, 1990; Egeland & Winer, 1974). Letters that are most difficult to discriminate are those that are left-right reversals of 1 another, such as b,d,p,q; sound similar, such as a, e, i, o, u; or look similar, such as f ,t , m, n, v, u (Gilbert, 1967;Griffiths & Griffiths, 1976). Accurate identification of each of these letters requires attention to the relevant characteristics of the letter, resulting in “an increase in specificity, which can be described as detection of properties, patterns, and distinctive features from an array of stimulation” (Egeland et al., 1974, p. 144).

Traditional approaches, characterized by their use of trial-and-error learning, usually result in the learner receiving feedback for correct responses, but no information about why their response was correct or incorrect (Bradley-Johnson et al., 1983; Egeland et al., 1974). Egeland and Winer (1974) provide an explanation supporting this point:

It is possible that the child could make the correct response without being aware of the salient cue that differentiates 1 stimulus complex from another. In the case of the incorrect response, the child is given negative feedback, presented with the same task on another occasion, and is seldom taught the distinctive features of the stimuli that must be recognized in order to make the correct discrimination. Incorrect responses indicate that the child has responded to a cue that provides irrelevant information for making the correct discrimination (144).

As determined by Sidman and Stoddard in 1966, trial-and-error learning is characterized by frequent errors, which only results in more errors. Frequent errors lead

to “frustration,” “aggression,” “tantrums,” “apathy,” and “self-injury” (Bradley-Johnson et al., 1983; Touchette & Howard, 1984) as well as long latencies to respond (Fabrizio, 2003; Terrace, 1963b) and greater durations when stimuli are presented in timings (Fabrizio, 2003).

Evidence suggests that errors made while acquiring complex discriminations may be reduced by modifying the teaching techniques used. Touchette and Howard (1984) described the study conducted by Terrace (1966) where pigeons that were trained to make a discrimination with trial-and-error learning emitted “agitated” and “aggressive” responses. This is in contrast to pigeons described as “calm” and “attentive” that were trained the same discrimination using an errorless technique. Errorless techniques result in a high probability that the participant will attend to S + (stimulus associated with reinforcement) when simultaneously presented with S+ and S- (stimulus associated with extinction) (Terrace, 1963a). According to Lancioni and Smeets (1986), all errorless procedures share the same objective: to train a response to accuracy with lower than 10% of total incorrect responses. Two specific rules must also be inherent in the procedures. First, the discrimination is designed to ensure accurate responding. “The subject is not immediately presented with the final (criterion) discrimination (as it occurs in trial-and-error training), but with a discrimination appropriate to his/her current level of functioning” (Lancioni et al., 1986, p. 136). Second, the steps are changed gradually until the final discrimination is presented (Lancioni et al., 1986).

Errorless procedures such as stimulus shaping, stimulus fading, superimposition and shaping, and delayed cue have successfully been utilized to train discriminations of length, size and numerosity, spatial relations, numbers, letters and words, shapes or



other configurations, sounds, body positions, mathematical problems, verbal instructions, and manual signs [refer to Lancioni and Smeets (1986) for a complete review of this literature]. Terrace (1963 a,b) determined, when comparing trial-and-error to stimulus fading that stimulus fading produced shorter latencies to respond, an increase in rate, errorless performance and no “emotional” responses. Sidman and Stoddard (1966) compared stimulus shaping to trial-and-error to teach a discrimination reversal between circles and ellipses and were successful in teaching 2 individuals with developmental disabilities the discrimination using a stimulus shaping procedure. Schilmoeller, Schilmoeller, Etzel and LeBlanc (1979) determined that more participants who were initially trained by stimulus shaping acquired the conditional discrimination of shapes than did those initially trained with stimulus fading or trial-and-error. Mosk and Bucher (1984) compared prompting to stimulus shaping to teach visual-motor skills and concluded that stimulus shaping was more efficient, resulted in fewer errors made, and a greater density of reinforcement. Duffy and Wishart (1987) compared trial-and-error to stimulus fading to teach shapes and concluded that stimulus fading was “superior” and that performance on trial-and-error adversely affected performance over time. Browder et al. (1990) however, compared stimulus shaping, stimulus fading, time delay and trial-and-error to teach the visual discrimination of sight words and concluded that no 1 approach showed a clear advantage over the others and that there were clear individual differences.

Most relevant to the present investigation, a small body of literature exists using both errorless and trial-and-error teaching methods to teach letter discriminations. Egeland and Winer (1974) compared errorless to trial-and-error training to teach 64

inner city preschool children 4 letter combinations (R-P, Y-V, C-G, and K-X). The discrimination was taught using a match-to-sample format, where in the child had to match the sample letter to the correct letter on a comparison card. The sample consisted of the correct choice and an incorrect choice. In the errorless group, the important characteristic of each letter to be discriminated was highlighted in red. Over trials the red was faded. The experimenters concluded that participants in the errorless group made fewer total errors and had better retention when compared to those in the trial-and-error group.

Griffiths and Griffiths (1976) compared stimulus fading to trial-and-error methods to teach letter discriminations to 6 typically developing nursery school children. The target letters were left-right reversals of each other (b-d and p-q) and were taught within a counterbalanced, within-subject experimental design. All of the children acquired the discrimination with fewer total errors and in fewer trials to criterion with the stimulus fading procedure. When the children were asked which procedure they preferred, all responded with stimulus fading.

Bradley-Johnson et al. (1983) compared 2 errorless procedures, delayed prompting and stimulus fading, to teach 39 preschoolers easily confused letters and numbers. Children were randomly assigned to 1 of 3 groups: stimulus fading, delayed prompting, or control group. Children in the delayed prompting group made fewer errors on the posttests than children in the stimulus fading group.

It is clear that errorless teaching methods are highly successful when compared to trial-and-error teaching methods. However, results across studies are inconsistent in their findings on which errorless technique is most effective. Inconsistencies that

emerged in the stimulus fading literature as the body of research grew are reported to have led to the development of stimulus shaping, a term coined by Sidman and Stoddard in 1966 (Lancioni et al., 1986). Stimulus shaping begins with presenting stimuli that the learner is already able to identify and that are easy to discriminate. The topography of the stimulus is slowly changed across successful learning trials until the final target discrimination is presented (Etzel, 1997; McCartney & LeBlanc, 1997; Schilmoeller et al., 1979). Stimulus shaping always emphasizes a “criterion-related cue” in each stimulus, which is characterized by 3 general rules: 1) changes very slowly across trials; 2) is emphasized in each trial and; 3) forms the basis on which the final, more difficult discrimination can be made (Etzel, 1997; McCartney & LeBlanc, 1997).

One such example of stimulus shaping to teach difficult letter sound - discriminations was developed by Gilbert in *The Mathetical Beginning Reading System*. A picture alphabet is used as a *mediation system*, which is the “use of knowledge already in the student’s repertoire to stimulate the learning of new material” (Gilbert, 1967, p. 2). Gilbert states, “We mediate an  $S^D \rightarrow R$  connection by finding another response in the students’ repertory that is already well conditioned to the stimulus and forms an easy association” (Gilbert, 1978, p. 289). Each mediator is a picture of something that the learner is already able to recognize, and it represents 1 letter from the alphabet. The shape of the picture has to be topographically similar to the letter it represents, and the picture’s name must also start with the same letter sound as the letter being taught. The known stimulus is then gradually changed to avoid any errors on the part of the learner. Stimuli that are most easily confused are “competitively” grouped together either because they look or sound similar, to facilitate the

discrimination. Each symbol represents only 1 sound. This avoids any confusion associated with 1 symbol representing 2 or more sounds or 1 sound being spelled multiple ways. Typically children are shown a set of 7 pictures and taught each picture's name. Second, the children are shown the same pictures and asked to say their names, emphasizing the initial sounds (e.g., "d-d-d duck"). After 2 to 3 trials, when the children are successful, they are asked to say only the initial sounds as they are shown the pictures (e.g., say "ě" when shown picture of elephant). Next the children listen to the initial sound and select the picture that matches it. This is done repeatedly until the children can quickly select the picture which matches the initial sound by drawing a circle around it. Over trials, the topography of the picture changes until it becomes the corresponding letter. Lastly, from dictation the children write sentences that consist of the letters which they were just taught. Gilbert states that this teaching method is "less confusing,...much more rapid,... and much better remembered" than traditional approaches (Gilbert, 1967).

Although the research is clear that errorless training produces accurate responding with fewer total errors and fewer trials to criterion than trial-and-error procedures, there are 2 documented disadvantages. First, the time, cost, and effort to prepare the training materials are initially much greater than for traditional trial-and-error methods (Bradley-Johnson et al., 1983; Browder et al., 1990; Keel, Loorland, & Fueyo, 1997). Second, Duffy and Wishart (1987) reported on research that suggests that errorless learning does not generalize to other tasks or even to post-tests of the same task.

In contrast, fluency-based instruction, which can be classified as trial-and-error learning, “ensures students permanently retain the skills they have learned, can perform them for extended periods, and can easily apply them to known and to new situations” (Johnson, 1997, p. 32). Binder (1996) operationally defines behavioral fluency as a “combination of accuracy plus speed of responding that enables competent individuals to function efficiently and effectively in their natural environment” (p. 163). Supporters of fluency-based instruction report that it is time-and-cost effective, that it requires little time to implement each day (Binder, 1996) and that students preferred this method twice as much as traditional methods (Bower, 1981). Addressing the high frequency of errors made by students exposed to fluency-based instruction, Bower (1981) states, “Well designed curricula and learning environments along with sufficiently high aims for correct response frequencies may make attending to errors both unnecessary and counterproductive” (p. 9). Binder (1996) also addresses the issue by recommending shortening the teaching session and breaking skills into smaller parts to facilitate acquisition and decrease any maladaptive behavior that may be associated with trial-and-error learning. Even with these adjustments, performance is still characterized by higher rates of errors and fewer corrects than that observed with errorless teaching methods. Because it is well agreed upon that acquisition of a skill first requires that the skill be performed accurately before it can be performed fluently (Fabrizio, 2003; Fabrizio & Moors, 2003), methods that produce accurate performance with few to no errors should be utilized to facilitate acquisition before implementing fluency building techniques.

Keel, Koorland and Fueyo (1997) report a study that compared an errorless procedure to fluency-based instruction to teach acquisition. In this study, stimulus fading is compared to fluency-based instruction to teach math facts to accuracy to three 4<sup>th</sup>-grade students. Within a multielement design, students were presented with multiplication problems on flashcards. The 5-step fading procedure included presenting the math problem with the answer displayed. The answer was gradually faded until only the math problem itself was showing. The fluency based instruction condition consisted of presenting the same flashcards within a 5-min timed session, but without the answers. In both conditions feedback was provided on whether or not the response was correct. The authors concluded that stimulus fading resulted in faster acquisition of math facts for 2 of the 3 participants; whereas, the third participant acquired the math facts faster under the fluency-based instruction. When children were asked which method they preferred, 1 participant responded with stimulus fading, another with fluency-based instruction and the third was undecided.

When the issue is not fluency, but initial skill acquisition, research is unclear on which method is more efficient in producing accurate responding that generalizes and is retained over time when teaching difficult letter-sound discriminations. Research is also limited concerning intraverbal formulation (See Peterson, 1978; Skinner, 1957 for discussion of “intraverbal”) or the ability to mediate in young children as discussed by Gilbert. Therefore, in the present investigation, the effectiveness of a stimulus shaping procedure derived and modified from Gilbert’s (1967) *The Mathetical Beginning Reading System* (described above) was compared with that of fluency-based instruction (trial-and-error learning) to teach difficult letter-sound discriminations. The main

differences between the current investigation's use of stimulus shaping and that of Gilbert's method were children were shown 6 pictures vs. 7 pictures; were not required to write stimuli in isolation or in sentences; were administered each step of the shaping sequence until the child's performance was 100 % accurate vs. both accurate and quickly; were taught using hear/point versus hear/write learning channels; and were exposed to 2 additional steps where the stimulus was taught via "learning by exclusion." Please refer to the methods section for a complete description of procedures.

The purpose of the current investigation was to extend the research using stimulus shaping with young children; compare the effectiveness of stimulus shaping to trial-and-error learning for initial skill acquisition of difficult letter- sound discriminations; test for mediation with the stimulus shaping method; test for retention and generalization across methods; and determine preference for stimulus shaping or trial-and-error learning.

## CHAPTER 2

### METHOD

#### Participants

Thirteen typically developing preschool children were selected by their teachers as potential participants. Each child was identified as having a deficit in recognizing or naming letters and their corresponding sounds. Each child was then assessed to determine eligibility. Each child was asked to provide both the letter name and corresponding sound for 12 letters. Four children who identified 2 or fewer sounds from each set of 6 stimuli were included in this study. These 4 were female with ages ranging from 4 years, 3 months to 4 years, 5 months. Three of the participants were African American and the fourth was Hispanic. All participants were assigned to the same preschool classroom. There was no known diagnosis for each child, however 1 participant was highly distractible and had difficulty attending for more than a few seconds at a time.

#### Setting

Experimental sessions were conducted in a small room containing 1 file cabinet, 3 large storage bins containing school supplies, 1 child-sized table and 3 small chairs: 1 for the experimenter, 1 for the child, and 1 for an observer periodically present in the room. This room also contained a bathroom, which the child could request to use anytime during the session. The child always faced the experimenter on the same side of the table. When present, the observer was positioned behind the participant approximately 6 ft away. Sessions were generally conducted once a day, 5 days/week,



and lasted for 5 to 25 min. The average session length was 5 min for CJM, 9 min for CJR, and 10 min for both CTS and CEN. Sessions began no earlier than 8:00 a.m. and were not conducted after 10:30 a.m. Children did not participate in any particular order due to uncontrollable variables such as attendance, time of arrival, and class activities which prevented the child from leaving class.

## Materials

### Pre-Training Stimuli

Six “known” pictures (i.e., tiger, ball, sun, mouse, fire truck and star) and 6 arbitrary pictures (refer to Fig. 1) were used as pre-training stimuli in this experiment. Each picture was created using a common word-processing software program. Pre-training stimuli were used in 3 formats. In the first format (i.e., flash cards) each picture was printed out in colored ink on 8.5 X 11 inch copy paper, measured and cut to 2 X 2 inch dimensions. Each picture was centered on the card’s front leaving the back of the card blank. All cards were then professionally laminated for durability. In the second format, each picture was arranged in 2 rows of 3, organized horizontally across the paper. Each set of 6 was printed out on 8.5 X 11 inch copy paper. In the third format, pictures were arranged in a circle consisting of 30 pictures (refer to Fig. 2).

### Stimuli

Twelve letters in Helvetica Narrow 130 pt font (refer to Fig. 3) were used as stimuli in this experiment. Letters were divided into 2 sets of 6. Set 1 consisted of letters *d p b v o u* and Set 2 consisted of letters [f s t e a i]. Each set of letters was taught using

several formats. In the first format, each stimulus (flash card) was created using a common word-processing software program. All 12 stimuli were printed out in black ink on 8.5 X 11 inch copy paper, measured and cut to 2 X 2-inch dimensions. Each letter was centered on the card's front leaving the back of the card blank. All cards were then professionally laminated for durability and cut to 2 X 2-inch dimensions. Six cards were constructed for each letter resulting in 36 flashcards for each set. In the second format, each letter was printed in isolation, centered on 8.5 X 11-inch copy paper. In the third format, letters were arranged in 2 rows of 3, organized horizontally across the paper. Each set was printed out on 8.5 X 11-inch copy paper. In addition to each of the 12 letters, 12 additional stimuli used consisted of pictures of an elephant's face, an apple, a snake, a flag, an Indian, and a table, a boot, a duck, a pipe, an octopus, a valentine, and a man pointing up (refer to Fig. 4). Each of these stimuli was the same size and color as each of the 12 letters. Each stimulus was initially presented once in isolation, centered on the paper. Each set of stimuli was then presented in 2 rows of 3, organized horizontally across the paper. An additional 24 stimuli were used where the first 12 resembled the original pictures (e.g., apple) and the last 12 were faded to resemble the original 12 letters being taught.

### Reinforcers

Candy, stickers, pencils, fake tattoos, and folders were all maintained in a clear plastic box (i.e., prize box) containing a green removable lid. The prize box was locked in the kindergarten teacher's office at the end of each day and was retrieved each morning prior to the first experimental session. The prize box was initially in view of the

children during the sessions, but was later moved out of view when children were looking at the box and talking about the items in the box during the experimental session. Each child was asked daily about what kind of items they would like to have in the prize box. All items were approved by the school staff and legal guardians of each participant.

### General Materials

Clear protective sheets sized 8.5 X 11 inches, a large green 3-ring binder, 2 standard digital timers, 8 standard celeration charts, 4 daily timings charts and data sheets. Data sheets were developed for interobserver agreement, pre, post, and retention tests and each trial of the errorless teaching format.

### Measurements

Measures used were frequency of correct and incorrect responses/min, frequency of trials, timings and practice opportunities, and duration of total instructional time. Correct, incorrect and skipped responses were recorded, as was participant preference.

### Sessions

Two sessions were conducted each day, where each teaching format equates to 1 session. An “errorful” session may consist of no more than 3 30-s timings and 9 practice opportunities (see below for definitions of timings and practice opportunities).

An “errorless” session typically consisted of 2 sub-sessions (i.e., 1 sub-session = 6 trials).

### Correct Response

A correct response was recorded when the participant accurately vocalized the correct letter sound corresponding to the letter being presented by the experimenter on the flashcard. For example, saying “ă” when presented with *a* or saying “b” when presented with *b*. In order for the response to be scored correct, it had to occur within 3 s of the stimulus presentation. A correct response was also recorded when the participant accurately pointed to the correct stimulus (i.e., picture or letter) with her pointer finger when the instruction “point to \_\_\_\_” was given. In this hear/point format, participants were prompted to respond if they had not within 3 s. Frequency and rate of correct responses were calculated for each session.

### Incorrect Response

An incorrect response was recorded when the participant behaved in any way other than what was defined above as a correct response. This included vocal responses such as “skip” or “I don’t know,” pointing to a letter that did not correspond to the letter sound provided, pointing to 2 or more letters at the same time, vocalizing a sound which was not the corresponding sound of the letter being presented, or providing no vocal or motor response. Frequency and rate of incorrect responses were calculated for each session.

## Skip Response

In each session, skip responses were recorded when the participant said “skip” immediately following the presentation of a stimulus.

## Session Duration

The duration of each individual teaching method was recorded on a digital timer. The start button on the timer was pushed when both child and experimenter were sitting across from 1 another, all materials were laid out on the table in front of the child, and the child had responded “Yes” when asked, “Are you ready to begin?” The timer was immediately stopped following the participant’s last recorded response. The timer was also stopped for any breaks that the child requested, including using the restroom or getting a drink of water. Breaks were not always vocally requested and, therefore, the timer was also stopped if the child got up from her seat and walked away from the table. This occurred with 1 of the 4 participants at least once during each session.

## Participant Preference

Initiated at Session 2, preference for each participant was assessed at the start of each experimental session by asking each participant, “Would you like to do cards first or pictures?” The participant’s response was immediately recorded and the teaching method chosen was then conducted.

## Timing

A timing was defined as a 30-s duration initiated by the experimenter pressing

the start button on the digital timer, followed by a series of stimulus presentations administered via flash cards. When the timer beeped, the timing was terminated and stimuli were no longer presented. No more than 3 timings were administered on any given day. A daily goal was set based on a participant's previous data. Once the goal was met, the session would be terminated. Specifically, if the participant met her goal on the first timing, then the session would be terminated and reinforcement would be delivered.

### Practice Opportunity

A practice opportunity is the term used to describe the presentation of each individual flashcard 3 times preceding the first timing and in between timings. 1 practice opportunity equates to a letter set being presented once. Frequency of practice opportunities were calculated for each session.

### Interobserver Agreement

Interobserver agreement (IOA) was collected for 36-40% of instructional sessions for 3 participants and 6% for the fourth participant. IOA was also collected for each assessment, pre-test, post-test, and retention test for 3 of the 4 participants. Post-test and retention test scores were not obtained for CJM due to early withdrawal from the school's summer program. Two graduate students from the Department of Behavior Analysis were trained as observers. Each observer was familiar with the teaching methods, but required training from the experimenter on how to use the data sheets and which behaviors to record. All observers were trained immediately preceding the

experimental session without participants present, provided time to ask questions, and were given materials needed to collect the data. Each observer was instructed to begin taking data when the experimenter hit the start button on the duration timer. Behaviors measured for reliability were duration of instructional session, number of timings, correct, incorrect, skip, and participant preference. All observers sat approximately 6-ft behind the participant in order to reduce any reactivity on the part of the participants and to ensure that all data being recorded by the experimenter was out of the view of the second observer. Reliability was calculated immediately following each experimental session using the formula:  $\frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100$ . Reliability was 100 % for each test session across all participants. Reliability ranged from 96% to 100% across the 4 participants. The fourth participant, CTS, would not respond in the presence of the graduate assistants; therefore, the classroom teacher was enlisted and trained to ensure reliability was collected for all tests administered as well as for 1 instructional session.

## Procedure

### General

Two experimental sessions were conducted each day wherein 2 to 3 timings in the “errorful” format were conducted either immediately before or immediately following the 2 sub-sessions in the “errorless” format. The order in which the teaching formats were conducted was determined by participant preference. Sessions were typically conducted between the hours of 8:00 a.m. and 10:30 a.m. Monday through Friday and

lasted on average 5 to 10 min. Each teaching format was conducted only once on any given day. On several occasions, teaching formats were taught within a several hours of 1 another due to unforeseen variables such as special outdoor activities. When this occurred, efforts were made to conduct the next session as soon as possible that same morning.

## Pre-Training

### General

Pre-training was designed to expose each participant to the hear/say, see/say, hear/point, and see/point/say learning channels while at the same time specifically teaching the “skip” response. Known and unknown or ambiguous stimuli were used in the pre-training to make the probability of responding or identifying a known stimulus (e.g., picture of a soccer ball) more likely and the response of “skip” less likely under those conditions. Similarly, unknown stimuli (e.g., experimenter instructs, “Point to zook”) when presented with an array of known and unknown stimuli would make the “skip” response more probable than either no response or simply guessing what the stimulus was. Any responses other than “skip” to unknown/ambiguous stimuli were noted but feedback was not delivered. All visual and auditory stimuli were identical across learning channels. Each format was conducted in the context of a 30-s timing. The pre-training began when experimenter and participant were seated at the table, with the pre-training materials positioned in front of the participant, and the timer was preset for 30 s.



## Hear/Say

The session began when the experimenter gave the following instructions, “I am going to say a word, and I want you to repeat the word that I say. For example, if I say dog, then you say dog. If you do not know how to say the word, or if you do not want to say the word you may say skip. Are you ready to begin?” Once the participant answers with “yes” the experimenter then states to the participant, “Now we are going to hear a word and try to say that word or say skip as fast as we can. Ready, set GO!” The 30-s timing began with the participant’s first response. If the participant did not respond for 3 s at any point during the timing, she was prompted to say “skip.” The skip response terminated that stimulus presentation and was followed by the next word on the list. 1 syllable-words were presented initially (e.g., ball, dog), but were quickly followed by words with multiple syllables (e.g., provenance, iliocostalis dorsalis). When the timer indicated the end of the timing, correct, incorrect, and skip responses were tallied.

## Hear/Point

Hear/point was immediately administered following hear/say. An array of known and unknown stimuli were arranged on 8.5 X 11 inch paper and was positioned in front of the participant. The session began with the following instructions, “I am going to say a word and I want you to point to the picture of the word I say. For example, if I say point to ball, then you do this (experimenter points to ball with pointer finger). If you do not know what the picture is, then you can say ‘skip.’ Are you ready to begin?” Once the participant answers with “yes,” the experimenter then states to the participant, “Now we are going to hear and point to the picture or say ‘skip’ as fast as we can. Ready, set

GO!” The 30-s timing began with the participant’s first response. If the participant did not respond for 3 s at any point during the timing, she was prompted to say “skip.” In addition to there being unknown pictures among known pictures, unknown words (e.g., zook, gad, ada, blop) were also utilized. For example, the experimenter would instruct, “Point to zook” making the skip response more probable. When the timer indicated the end of the timing, correct, incorrect, and skip responses were tallied.

### See/Say

See/say was immediately administered following hear/point and began with the following instructions, “I am going to show you some cards, like this 1 (experimenter holds up card), and I want you to tell me the name of that card. So if I hold up this card (picture of a ball), then you would say ball. If you do not know what the picture is then you may say skip. Are you ready to begin?” Once the participant assents, the experimenter states, “Now we are going to see and say the picture or say skip as fast as we can. Ready, set GO!” The 30-s timing began with the participant’s first response. If the participant did not respond for 3 s at any point during the timing, she was prompted to say “skip.” Correct, incorrect, and skip responses were tallied when the timer indicated the end of the timing.

### See/Point/Say

See/point/say was administered last and the experimenter gave the following instructions, “You are going to point to each picture on this circle and say the picture’s name. If you do not know what the picture is, you can say ‘skip.’” The experimenter then

modeled pointing in order of stimulus presentations and allowed the child to practice pointing to ensure that each participant understood. The participant was then asked, “Are you ready?” Once the participant responded “yes,” the experimenter stated, “Now we are going to point and say the picture or say skip as fast as we can. Ready, set GO!” The 30-s timing began with the participant’s first response. If the participant did not respond for 3 s at any point on the circle, she was prompted to say “skip” by the experimenter. When the timer indicated the end of the timing, correct, incorrect, and skip responses were tallied.

### Pretest

A pretest to obtain baseline performance was conducted prior to the first session to test all 12 target letter sound discriminations in the see/say, hear/point and see/point/say learning channels. Pre-training began when both experimenter and child were seated in chairs, facing each other and approximately 1 ft from each other; the second data collector was seated approximately 6 ft behind the participant; the timer was preset for 30 s; all data collection materials were in place; and the 3-ring binder containing all stimuli was appropriately placed in front of the participant. Hear/point was conducted first and began with the following instructions, “I am going to say a letter sound and I want you to point to the letter you think it is. If you do not know, you can say skip. Are you ready?” Once the participant stated that she was ready, the experimenter instructed, for example, “Point to f.” If the participant pointed to the letter f, no feedback was provided and the next trial or instruction (e.g., “Point to s”) was administered by the experimenter. If the child responded with “skip,” did not respond (i.e., did not point to

stimuli in the array), pointed to 2 or more letters at the same time or pointed to any other letter (e.g., a, e, i, s, or t), no feedback was provided; the response was scored and the experimenter initiated the next trial. The session was terminated after all 6 stimuli had been presented. Correct, incorrect, and skip responses were tallied at this time. The same procedure was then repeated with letter set **b p d v o u**.

See/point/say was administered next. Once again, the 3-ring binder was open and in front of the participant. The 6 stimuli were arranged in a circle made up of 30 stimulus presentations (Refer to Fig. 4). The experimenter gave the following instructions, "You are going to point to each letter on this circle and say the letter sound. If you do not know the letter sound, you can say 'skip.' Are you ready?" Once the participant responded "Yes," the experimenter stated, "Now we are going to point and say the letter or say skip as fast as we can. Ready, set GO!" The 30-s timing began with the participant's first response. If the participant did not respond for 3 s at any point on the circle, she was prompted to say "skip." When the timer indicated the end of the timing, correct, incorrect, and skip responses were tallied. The same procedure was repeated with the second letter set **b p d v o u**. See-say was conducted last and began with the following instructions, "I am going to show you a letter and I want you to tell me the sound. If you do not know the sound, you can say skip. Every letter that you get right, I will drop in the bag you are holding. Are you ready? Now we are going to see and say as fast as we can with a timer." The experimenter held the stack of 36 cards, letter set **f s t e a i** and said, "Ready set GO!" The 30-s timing began with the participant's first response. All correct responses resulted in the card being dropped in the bag the child was holding. All incorrect responses were dropped to the floor. This

procedure was developed to facilitate a fast transition between stimulus presentations and to ensure accuracy of data collection. If the participant did not respond within 3 s, she was prompted to say “skip” and the card was dropped to the floor. When the timer indicated the end of the timing, the same procedure was repeated with the second letter set **b p d v o u**. Following the completion of each test the participant was praised regardless of performance on each task. No consequences were delivered for incorrect responses. Participation was rewarded with a choice from a prize box containing candy, stickers, pencils, fake tattoos, and folders. Each child was asked daily about what kind of items they would like to have in the prize box.

#### Post Test

The post test was identical to the pre-test and was administered to 3 of the 4 participants. The post test session was administered on the Monday following the last teaching session the previous Friday.

#### Retention Test

Thirty days following the last teaching session, the 3 remaining participants were administered the same series of tests presented in both the post and pretests. Retention of all 12 letter sounds were assessed at this time.

#### Generalization Test

The 12 stimuli tested in the see/point/say learning channel in both the post and retention tests served as a test of generalization across learning channels.

### Errorful Teaching Procedure

On Day 1 of the errorful teaching procedure, the experimenter shuffled 6 stimulus cards (1 flash card for each letter) for the corresponding letter set. The experimenter then stated to the participant, "I am going to show you a letter. I am then going to say the sound it makes and then you say the sound that I made." For instance, the experimenter held up the letter f and said the sound for f. If the participant imitated the sound for f accurately, praise was provided. If the participant did not respond for 3 s, the skip response was prompted. If the participant said the sound incorrectly, the trial was repeated. All 6 letters were presented. The 6 cards were then shuffled and the experimenter instructed, "See if you can say the letter sound before I say it." The experimenter then held up a card and if no response occurred within 3 s, the experimenter stated the letter sound and prompted the participant to say the correct response. Praise was then provided. This was repeated until all 6 letter sounds had been presented.

For all sessions following Session 1, the experimenter shuffled the 6 flashcards and then instructed, "See if you can say the letter sound before I can say it," and if the student did not respond within 3 s the experimenter said the letter sound, prompted the participant to model the correct response and then administered praise. Each flash card was presented 3 times prior to each 30-s timing (i.e., practice opportunities). No more than 3 timings were administered on any given day. If the participant met the goal set for that day in the first or second timing, the session was terminated.

Each of the daily 30-s timings began with the following instructions, "I am going to show you a letter and I want you to tell me the sound. If you do not know the sound,

you can say skip. Every letter that you get right, I will drop in the bag you are holding. I want you to try to do the best that you can. Are you ready? Now we are going to see and say as fast as we can with a timer.” The experimenter, sitting directly in front of the participant held the stack of 36 stimulus cards (6 of each letter in the set) and said, “Ready set GO!” The first card in the deck was presented and the 30-s timing began with the participant’s first response. Correct responses resulted in the card being dropped in the bag the child was holding. Cards responded to incorrectly were dropped to the floor. Once the timer sounded, the trial was immediately terminated. Both the experimenter and participant counted the number of correct responses. Incorrect responses were then counted by the experimenter and all data were recorded. For all participants, 3 daily timings were conducted for Session 1. The total correct and incorrect responses/day were plotted on a standard celeration chart and each individual timing was plotted on the daily timings chart. A daily goal based on previous performance from the prior session was set after Session 1 on all subsequent sessions. For example, if the participant responded correctly 3 times in 30 s then the goal would be set at 4 correct responses for the following session. Once the goal was met, the session was terminated; however no more than 3 timings were administered in any given session. Therefore, if a goal was not met the same goal would be set for the following session.

A modification to this procedure was implemented for 3 of the 4 participants due to a high rate of errors. Target letters were reduced for each of these participants from 6 letters to 2 letters for CJR and from 6 to 3 letters for both CTS and CEN. Target letters selected were based on individual performance. Specifically, letters were chosen which

were already acquired with 1 additional letter which was not acquired. Initial criterion for adding an additional letter was 2 or fewer errors across 2 consecutive days. Due to unforeseen time restrictions, 1 letter was added each experimental session during the last week of the experiment until all 6 target letters were presented.

### Errorless Teaching Procedure

The errorless stimulus shaping procedures utilized in this study were derived and modified from Gilbert's (1967) *Praxis Reading Series*. During the first session only, a pretest was administered during which each picture in either set 1 (boot, pipe, duck, valentine, octopus, man pointing up) or set 2 (flag, snake, table, elephant, Indian, apple) was presented in isolation, and the experimenter asked the participant, "What is this?" If the child responded with the label assigned to the picture (i.e., said "Indian" when shown picture of Indian," then the experimenter responded with, "That's right! That is an Indian. If the participant did not respond or said something other than Indian such as "I don't know," "skip," or "a man" the experimenter said, "That is an Indian. Say Indian." If the child did not imitate the name within 3 s, then the instruction, "say Indian" was repeated. Once all 6 pictures had been accurately identified using the assigned label for each picture, then the errorless procedure was implemented in a hear/point format. 100 percent accuracy across all 6 stimuli was obtained before beginning the errorless procedure. The errorless procedure is comprised of 12 steps which are classified as either auditory stimulus shaping or visual stimulus shaping steps. These will be described further below.



## Auditory Stimulus Shaping

First, the auditory stimulus (i.e., letter sound) was shaped over a series of 6 steps (refer to sequence of Steps 1-6 below). Stimuli were arranged 3 across and 2 down on the page with positions changing for each step of the procedure. The visual stimuli did not change in form (i.e., picture of “apple” in Step 1 was identical to picture of “apple” in Step 6), however the positions of the visual stimuli change at each step (i.e., in Step 2, the apple was positioned in the middle on the second row and in Step 3, the apple was positioned in the first row on the far right). Instructions provided by the experimenter changed and were administered in the following sequence:

- Step 1: Experimenter instructs, “Point to apple” → Participant points to apple.
- Step 2: Experimenter instructs, “Point to ä- ä apple” → Participant points to apple.
- Step 3: Experimenter instructs, “Point to ä- ä apple” → Participant points to apple.
- Step 4: Experimenter instructs, “Point to ä- ä” → Participant points to apple
- Step 5: Experimenter instructs, “Point to “ä- ä” → Participant points to apple
- Step 6: Experimenter instructs, “Point to “ä” → Participant points to apple

## Visual Stimulus Shaping

The topography of 12 visual stimuli were gradually shaped from “known” pictures (e.g., apple) into corresponding target letters (e.g., a) over 4 stimulus manipulations (Refer to Fig. 5). The visual stimulus shaping procedure was comprised of 6 total steps with 3 out of the 6 steps classified as “exclusion” steps (Steps 8, 9, 10). The remaining 3 steps (Steps 7, 8a, 9a) will be referred to as stimulus shaping steps. The instruction provided by the experimenter (e.g., “point to ä”) remained constant. The steps were administered in the following sequence:

- Step 7: Stimulus Shaping. Experimenter instructs, “point to ä” → Participant points to apple (stimuli are topographically identical to stimuli presented in Steps 1-6) when presented in an array of 6 stimuli.
- Step 8: Exclusion. Six arrays are presented in sequence. In each array, the topography of 1 of the 6 stimuli changes and the remaining 5 stay the same (i.e. the stimuli the participant has already accurately identified). For example, the experimenter instructs, “point to ä” → Participant is presented with an array where the only picture whose topography has been modified is the picture of the apple. The remaining 5 pictures are identical in form to those presented in Steps 1-7. If the participant accurately identifies the apple, then the array is changed. The experimenter then instructs, “point to ě” → Participant is presented with an array where now both the topography of the apple and the elephant have been modified and the remaining 4 pictures are the same as in Steps 1-7. This step continues until the topography of all 6 pictures has been modified and each stimulus is correctly identified by the participant.
- Step 8a: Stimulus shaping. Experimenter instructs, “point to ä” → Participant points to apple (stimulus is topographically identical to modified stimuli in Step 8) when presented in an array of 6 stimuli.
- Step 9: Exclusion. Six arrays are presented in sequence as in Step 8. In each array, the topography of 1 of the 6 stimuli changes and the remaining 5 stay the same as presented in 8a (i.e. the stimuli the participant has already accurately identified). This step continues until the topography of all 6 pictures has been modified and each stimulus is correctly identified by the participant.
- Step 9a: Stimulus shaping. Experimenter instructs, “point to ä” → Participant points to apple (stimulus is topographically identical to modified stimuli in Step 9) when presented in an array of 6 stimuli.
- Step 10: Exclusion. Six arrays are presented in sequence as in Steps 8 and 9. In each array, the topography of 1 of the 6 stimuli changes and the remaining 5 stay the same as presented in 9a (i.e. the stimuli the participant has already accurately identified). This step continues until the topography of all 6 pictures

has been modified and each stimulus is correctly identified by the participant. The sixth and final array presented displays the terminal discrimination (i.e., 12 target letters).

One or fewer errors in any given step resulted in moving up to the next step in the 12-step procedure. If the same error was repeated or if 2 or more errors occurred, the previous step was reviewed for that session. For 2 of the 4 participants an additional procedure was needed (See “intraverbal” below) to facilitate accurate responding in Step 4.

#### Intraverbal/Mediation Training

Participants CJR and CEN were administered an additional procedure to teach the required intraverbal (e.g., “o – o octopus”) at Step 4 of the stimulus fading procedure. For each of the 6 stimuli, the intraverbal was first modeled by the experimenter (e.g., “I say “o-o” and you say and point to “octopus””), then the participant was asked to rehearse the response (e.g., experimenter says “o-o” and participant responds “octopus” and then points to the picture of the octopus). Testing was administered to test for acquisition. The test was identical to Step 4 of the errorless procedure. The experimenter instructed the participant to “point to “o-o.” If the participant correctly responded by pointing to the picture of the octopus across 3 trials, then the intraverbal was concluded to have been acquired. For each participant, the intraverbal was taught in 3 sessions.

#### Reinforcement

Participation was rewarded after both teaching procedures were conducted with

a choice from a prize box. Praise was also provided for “working hard” and was administered following each trial and session.

### Experimental Design

A multi-element design was utilized to compare the effects of errorless and errorful teaching methods on the acquisition, generalization and retention of letter sound discriminations. The 2 sets of letters and procedures which they were taught were counterbalanced across participants. Specifically, participants CEN and CTS were taught letter sounds bpdvou with errorful and taught fsteai with errorless. Participants CJM and CJR were taught letter sounds bpdvou with errorless and taught fsteai with errorful.

## CHAPTER 3

### RESULTS

Figures 6-9 show accuracy of responding for both errorless and errorful experimental conditions in addition to pre-test, post-test, and retention test data. Data for the errorless condition are displayed in the top chart, and data for the errorful condition are displayed in the bottom chart. Green indicates 100% correct responding for that session. Black indicates that the corresponding target letter was not presented for that session. Light blue indicates intraverbal training sessions. In all testing sessions, incorrect responses are indicated by the letter x and skip responses were indicated by the letter s. In the training trials, total number of errors made for that session corresponds to the number in the chart. Session date is displayed along the horizontal x-axis and target sounds and fading steps are displayed along the vertical y-axis.

Fig. 6 shows summary data for participant CJM. Results from the pre-test were as follows: letters v and b were correctly identified in the hear/point learning channel, but were not correctly identified in the see/say or see/point/say learning channels. The remaining 10 target letters were never correctly identified in any of the learning channels; responses were either incorrect or the participant responded with “skip.” Results from the errorless training condition indicated a high frequency of correct responses with 3 errors at Step 4, 1 error at Step 5 and 1 error at Step 8. 1 or more errors resulted in the same step being repeated the following session. Overall accuracy was calculated at 94 % for this condition. Criterion, defined as 100% correct responses in the hear/point learning channel across 6 target letters was achieved in 11 sessions. Results from the errorful training condition indicated 54 errors being made in the first 3

sessions, with 100 % correct responding at Session 4, followed by 1 or fewer errors for the remaining experimental sessions. Overall accuracy was calculated at 86% for this condition. Criterion, defined as 100% correct responding for all 6 target letters, was achieved in 4 sessions. This definition applies only to participant CJM, who acquired the letter sound discriminations across all 6 target letters before the end of the experimental condition. Rate/min, although measured, is not included in the criterion definition. For the purposes of this study, accuracy is of main importance. Post-test and retention test data are not available for this participant due to early withdrawal from the school. When this participant was provided with a choice of which procedure was preferred, the errorful procedure was selected on 66 % of sessions.

Fig. 7 shows summary data for participant CJR. Results from the pre-test were as follows: letters u and e were correctly identified in the hear/point learning channel, but were not correctly identified in the see/say or see/point/say learning channels. The remaining 10 target letters were never correctly identified in any of the learning channels; responses were either incorrect or the participant responded with “skip.” Results from the errorless training condition determined 100 % accurate performance for Steps 1-3. Two errors were made at Step 4, 10 errors at Step 5 and then intraverbal training was implemented. During intraverbal training, 4 errors were made on the first session and 1 the following session; 100 % accurate responding followed until Step 8 where 3 errors were made. The step was repeated and was followed by 100 % correct responding for the remaining sessions. Criterion was achieved in 12 sessions. Total accuracy was calculated at 81.5%.

Results from the errorful training trials were characterized by a high number of errors. Consequently, number of target letters was reduced, resulting in the presentation of letters s and f alone. Performance improved and gradually target letters were added until all 6 target letters were presented. Criterion, defined as 100 % correct for each target letter across hear/point learning channel in the post test was met for each target letter. Overall accuracy for training sessions was calculated at 65%. Results of the post test and retention test for target letters taught in the errorless condition were as follows: All 6 target letters were correctly identified in the hear/point learning channels both at post-test and at the 30-day follow up (i.e., retention test). Zero letters were correctly identified in the see/say or see/point say learning channels. Thus, retention of letters was observed only in the learning channel in which these letters were originally taught. Generalization did not occur under these sets of conditions.

Results of the post test and retention test for target letters taught in the errorful condition were as follows: All 6 target letters were correctly identified in the hear/point learning channels both at post-test and at the 30-day follow up. Letters a, e, i, f, and s were correctly identified in the see/say learning channel in the post test. Letters e, i, f, and s were correctly identified in the see/say learning channel at the 30-day follow up. Letters a, i, f, and s were correctly identified in the see/point/say learning channel in the post test and letters a, f, and s were correctly identified in the see/point/say learning channel at the 30-day follow up. Retention and generalization occurred in the errorful condition. When the participant was provided with a choice of which was the preferred procedure, the errorless procedure was selected on 85 % of sessions.

Fig. 8 shows summary data for participant CTS. Results from the pre-test were as follows: letters **e**, **f**, **u**, **v**, and **p** were correctly identified in the hear/point learning channel, but were not correctly identified in the see/say or see/point/say learning channels. The remaining 7 target letters were never correctly identified in any of the learning channels; responses were either incorrect or the participant responded with “skip.” Results from the errorless training condition determined 100 % accurate performance for Steps 1-3. 1 error was made at Steps 4 and 8. Step 8 was repeated twice to ensure 100% accuracy for this step. 1 hundred percent accurate responding occurred for the remaining sessions. Criterion was achieved in 11 sessions. Total overall accuracy was calculated at 97.8%.

Results from the errorful training trials were characterized by a high number of errors. Consequently, target letters were reduced, resulting in the presentation of letters **o**, **v**, **p**, and **d**. Performance improved and gradually target letters were added until all 6 target letters were presented. Criterion, defined as 100 % correct for each target letter across hear/point learning channel in the post test, was met for each target letter. Overall accuracy was calculated at 65%.

Results of the post test and retention test for target letters taught in the errorless condition were as follows: Target letters **a**, **i** and **t** were correctly identified in the hear/point learning channel and letter **t** was correctly identified in the see/say learning channel at post-test . At the 30-day follow up (i.e., retention test) no letters were correctly identified in the see/point say learning channel. Letter **t** was identified in both the see/say and hear/point learning channel and letter **a** was correctly identified in the hear/point learning channel. Retention of letters **a** and **t** occurred in the hear/point



learning channel they were originally taught. Generalization did not occur under these sets of conditions. Results of the post test and retention test for target letters taught in the errorful condition were as follows: All 6 target letters were correctly identified in the hear/point learning channels both at post-test and at the 30-day follow up indicating retention under these conditions. Letters o, u, v and p were correctly identified in the see/say learning channel in the post test and letters o, u, and v were correctly identified at the 30-day follow up. Letters o, u, v, b and p were correctly identified in the see/point/say learning channel in the post test and letters o, u and v were correctly identified at the 30-day follow up. Retention and generalization were identified to have occurred in the errorful condition for letters o, u and v. When the participant was provided with a choice of which procedure was preferred, the errorless procedure was selected on 79 % of sessions.

Fig. 9 shows summary data for participant CEN. Results from the pre-test were as follows: letters u, v and d were correctly identified in the hear/point learning channel, but were not correctly identified in the see/say or see/point/say learning channels. The remaining 9 target letters were never correctly identified in any of the learning channels; responses were either incorrect or the participant responded with “skip.” Results from the errorless training condition determined 100 % accurate performance for Steps 1-3. Seven errors were made at Step 4 before intraverbal training was implemented. During intraverbal training, 1 error was made on the first session and 2 the following session. CEN successfully completed Steps 4 and 5 the following session, but then required additional intraverbal training at Step 6. This training session was followed by 100 % correct responding for the remaining sessions. Criterion was achieved in 11 sessions.

Total accuracy was calculated at 90.8 %. Results from the errorful training trials were characterized by a high number of errors. Consequently, target letters were reduced, resulting in the presentation of letters **v**, **p** and **d**. Performance improved and gradually target letters were added until all 6 target letters were presented. One hundred percent accuracy was only achieved for letter **v**. Frequent errors were made for the remaining 5 letters throughout the experiment. Criterion, defined as 100 % correct for each target letter across hear/point learning channel in the post test, was not met for any target letter. Letters **v** and **p** were the only letters accurately identified in the hear/point learning channel in the post test. Overall accuracy was calculated at 37 %.

Results of the post and retention tests for target letters taught in the errorless condition were as follows: Target letters **a** and **e** were correctly identified in the hear/point learning channel at post-test. At the 30-day follow up (i.e., retention test) target letters **i** and **f** were correctly identified. No letters were correctly identified in the see/say or see/point say learning channels. Retention and generalization did not occur under these sets of conditions. Results of the post test and retention test for target letters taught in the errorful condition were as follows: target letters **v** and **p** were correctly identified in the hear/point learning channels both at post-test and at the 30-day follow up indicating retention under these conditions. Letters **v** and **d** were correctly identified in the see/say learning channel in the post test and letter **v** was correctly identified at the 30-day follow up. Letter **v** was the only letter correctly identified in the see/point/say learning channel in both the post test and the 30-day follow up. Retention and generalization were identified to have occurred in the errorful condition for letter **v** alone. Letter **p** was only identified in the hear/point learning channels, but did indicate

retention when correctly identified at the 30-day follow up. When the participant was provided with a choice of which procedure was preferred, the errorless procedure was selected on 100 % of sessions.

Figure 10 shows total correct and incorrect responses for both the errorless and errorful conditions for each participant in a stacked bar graph. Total practice opportunities (i.e., flash card presentations before and between timings) for the errorful condition are also displayed for each participant. Each condition across participants is displayed along the horizontal x-axis and total number of responses is displayed along the vertical y-axis. In the errorless condition, all participants learned the 6 letter sound discriminations with fewer total errors and with considerably fewer responses to criterion. Participant CJM made 5 errors and 85 corrects in the errorless condition and made 39 errors and 272 corrects in the errorful condition. This was the only participant to correctly identify all 12 letters with 100% accuracy on the last session preceding the post test. Participants CJR made 20 errors and 88 corrects in the errorless condition and 92 errors and 262 corrects in the errorful condition. Participant CTS made 2 errors and 70 corrects in the errorless condition and 89 errors and 253 corrects in the errorful condition. Participant CEN made 12 errors and 114 corrects in the errorless condition and made 89 errors and 141 corrects in the errorful condition. It is important to reiterate that participants CJR and CEN also received additional training to acquire the intraverbal for the errorless condition. CJR had made 12 errors preceding this training and CEN had made 7 errors preceding this training.

Figure 11 shows total instruction time for both errorless and errorful conditions for each participant. Each condition across participants is displayed along the horizontal x-

axis and total minutes displayed along the vertical y-axis. All participants had acquired the 6 letter-sound discriminations in fewer than 33 min of total teaching time in the errorless condition. This is in comparison to a range of 45 min for 1 participant to 130 min for another participant in the errorful condition. Participant CJM spent a total of 17 min in the errorless condition and 44.5 min in the errorful condition. Participant CJR spent a total of 29.5 min in the errorless condition and 83 min in the errorful condition. Participant CTS spent a total of 32 min in the errorless condition and 130 min in the errorful condition.

Figures 12-15 each show a daily per minute standard, 6-cycle semi-logarithmic chart that measures frequency as movements/time and celeration as movements/time/time. Successive calendar days are displayed along the horizontal x-axis and count/min is displayed along the vertical y-axis. Record floor is adjusted daily to reflect total number of corrects and incorrects calculated as rate per minute for both errorful and errorless conditions. Specifically, in the errorful condition if a participant completed 3 30-s timings for that day, the record floor was set at 90 s. If that same participant completed 2 30-s timings the following day, then the record floor was set at 60 s or 1 min. In the errorless condition, if the participant took 120 s to complete the corresponding step (i.e., duration measure), then the record floor would be set at 120 s or 2 min. Total corrects and incorrects for that session are calculated as rate/min and plotted accordingly. Although each experimental condition was run each day, charted data from each condition are shown separately, instead of overlaid on each day, for easier interpretation.

Figure 12 shows results for participant CJM. In the errorful condition (letter set: **f s t e a i**) both accuracy and rate are increasing steadily over sessions. Errors are initially high totally 13 errors on Day 1 with 12 correct responses. Rate is at 20/min. By Session 4, errors have decreased to 1 or less per session with rate calculated at 30/min. By Session 11, CJM has zero errors and a rate of 56/min. In the errorless condition (letter set: **b p d v o u**) accuracy is initially high, however rate is variable. Errors are at 1 or zero, typically zero for all sessions. Overall accuracy was calculated at 94 % for the errorless condition and 86% for the errorful condition. The mean rate/min for CJM in the errorless condition is 8.67 compared to a rate of 36.18 in the errorful condition.

Figure 13 shows results for participant CJR. In the errorful condition (letter set: **f s t e a i**) both accuracy and rate are steadily increasing over the first 8 sessions. At Session 9, rate has maintained and then decreases slightly over the next 4 sessions. Specifically, errors are initially high totally 24 errors on Day 1 with 8 correct responses. By Session 3, errors have decreased to 12, but accuracy is still low with 5 correct responses resulting in a rate of 10/min. The letter set was reduced to letters **s** and **f** for Sessions 4 and 5. This results in 1 error, 11 corrects and a rate of 22/min. Letter **a** is then added to the target letters **s** and **f**. At Session 9, the best timing of the day resulted in 3 errors and 16 corrects resulting in a rate of 32/min. At Session 10, the target letters consisted of **s f a e**. Errors were still at zero with rate calculated at 36/min. By Session 12, errors were still low (4 total errors for session) and 45 total corrects. Rate decreased slightly to 30/min. On the final session, all 6 target letters were presented. The final and best timing of the experimental condition resulted in 0 errors, 11 corrects and rate calculated at 22/min. In the errorless condition (letter set: **b p d v o u**), rate is variable,

with no clear increasing or decreasing trend. Overall errors were low following the intraverbal training and overall accuracy was calculated at 81.5%. In comparison, overall accuracy in the errorful condition was 65%. The mean rate/min for CJR in the errorless condition was 6.62 compared to a rate of 23.38 in the errorful condition.

Figure 14 shows results for participant CTS. In the errorful condition (letter set: **b p d v o u**) both accuracy and rate steadily increased over the first 12 sessions. Performance then leveled off and began to decline when the fifth and sixth target letters were added. Specifically, errors were initially high (15 total errors on Day 1) and 7 correct responses. At Session 8, the 6 target letters were reduced to **v**, **o** and **p**. CTS made 1 error and 9 corrects resulting in a rate calculated at 18/min. At Session 12, the targets included **v o p u**, and total errors for that session were 4 and total corrects were 34. The best rate for that session was 26/min. Letter **d** was then added and errors still remained low (two or less) for each individual timing. Rate maintained at 26/min. On the final day of the experiment, letter **b** was added. Total errors for that session, across 2 timings were 4. Total corrects were 10, with 5 for each timing. Rate had declined to 10/min. In the errorless condition (letter set: **f s t e a i**), overall accuracy was very high. Rate was variable with no clear indication of an increasing or decreasing trend. Two errors were made for the entire condition and overall accuracy was calculated at 97.8%. In comparison, the overall accuracy calculated for the errorful condition was 65%. The mean rate per minute for CTS in the errorless condition was 7.18 compared to a rate of 16.25 in the errorful condition.

Figure 15 shows results for participant CEN. In the errorful condition (letter set: **b p d v o u**) both accuracy and rate steadily increased across sessions until leveling off at

Session 8 and then decreasing with the addition of the fifth and sixth target letters. Specifically, errors are initially high totaling 14 on Day 1 with 5 correct responses. On Session 3 the 6 targets were reduced to v p d. By Session 8, errors had reduced to 2 with 12 correct responses resulting in a rate of 24/min. A fourth target (letter o) was then added. CEN made 1 error and 13 correct at that session. Letter u was then added as a target letter. Errors increased to 3 per individual timing and 8 correct resulting in a rate of 16/min. On the eleventh and final session, all 6 target letters were taught. The last timing of the condition was 8 correct, 1 incorrect and a rate of 16/min. In the errorless condition (letter set: f s t e a i), overall accuracy was high with few or zero errors. Rate was variable with no clear increasing or decreasing trend. Specifically, 11 errors were made for the entire condition and overall accuracy was calculated at 90.8 %. In comparison, the overall accuracy calculated for the errorful procedure was 37 %. The mean rate/min for CEN in the errorless condition was 5.6 compared to a rate of 8.27 in the errorful condition.

## CHAPTER 4

### DISCUSSION

Results of the present investigation demonstrated that difficult discriminations can be taught with minimal instruction using errorless procedures. Acquisition of 6 target letters was achieved in 11 sessions for 3 participants and 12 sessions for the fourth participant with total teaching time of 33 min or less per participant. Acquisition under the errorless condition was facilitated with the implementation of intraverbal training for 2 of the 4 participants at Step 4 of the procedure.

In contrast, acquisition under the errorful condition was variable across the same participants with only 1 of them acquiring all 6 letter sound discriminations. The remaining 3 participants made considerably more errors under this condition and never acquired all 6 target letters. Specifically, participant CTS acquired 5 of the target letter sounds; whereas, participants CEN and CJR acquired only 3 of the target letter sounds. A modification reducing the number of target letters for each participant was implemented to facilitate acquisition, and did result in fewer overall errors and faster acquisition when compared to sessions before this modification was implemented. Total teaching time under the errorful condition was also considerably greater with the shortest teaching time being 44.5 min and the longest teaching time being 130 min.

One implication of these results suggests that educators should assume that children who are 4 and 5 years of age will not readily discriminate between letters which are left-right reversals and/or are otherwise topographically and auditorially similar to 1 another without specific discrimination training. When letters look or sound similar the discrimination is more difficult and frequency of errors is high, as observed in the



present investigation. According to Gilbert (1967; 1978) these errors come about because the similar elements making up the stimulus “compete” with 1 another and this competition is the primary problem in beginning reading instruction. Gilbert (1978) discusses mediation as “A powerful method for overcoming competition...that will help associate a stimulus and response that are not usually associated with each other” (p. 289). Gilbert’s *mediation* system is the “use of knowledge already in the student’s repertoire” and uses *mediators* which are “learning bridges that help the student get from where he is to where he is going” (Gilbert, 1967, p. 2). More specifically, each mediator is a familiar picture, which serves as a “bridge” by gradually shaping the known picture into the target letter and the known sound into the target sound. The mediation system should result in associating the letter itself with the corresponding sound with few to zero errors (Gilbert, 1967).

In a later publication, Gilbert (1978) states that when using mediation, the teacher must look for something that will mediate an “ $S^D \rightarrow R$  connection by finding another response in the student’s repertory that is already well conditioned to the stimulus and forms an easy association” (p. 289). 1 potential limitation, directly related to the above discussion concerns the stimuli employed for the errorless stimulus shaping procedure. The first rule of thumb when selecting a mediator is that it is easily recognizable to the learner. There were initial errors made by the children when learning the names of the stimuli. For example, a picture of a pipe is used to teach the letter p. Both participants were not readily able to name this stimulus and additional teaching was required. A second stimulus that was difficult to learn was the picture of the man pointing up. Each child responded with “a man” when asked to identify the picture. The

fact that the man was pointing up had to be specifically taught. In the present case, errors may have been avoided if a series of stimuli were presented to the children to determine which were known (i.e., child could accurately label the picture without additional training) and which were unknown. As a prerequisite, the learner should readily identify all stimuli before beginning any stimulus shaping procedure. Schilmoeller (1979) addressed this issue and stated, "The issue of whether stimulus shaping would be as successful if the initial cues cannot be easily labeled by children remains to be resolved" (p. 418). Results of the present investigation suggest that under these circumstances the participants were successful with this method although additional training was implemented to teach the specific names of the stimuli. It may be argued, however, that to avoid additional errors on the part of the learner it would be more appropriate to use a picture of a popsicle, for example, to teach the letter p instead of a picture of a pipe because the popsicle may have a higher probability of being recognized.

Gilbert's program also requires a different type of mediation in order for the program to succeed: the control of our own verbal behavior over our other behavior. In the present investigation, 2 of the 4 children were not readily able to transition from "point to aa apple" in Step 3 to "point to aa" in Step 4 without errors. Children who had succeeded in this and other experiments addressed below usually provided the name of the picture (e.g., "apple") after they heard the instruction (e.g., "point to aa"). These 2 children did not and, therefore, have no basis on which to select the correct picture. Pilot work (implemented by Dr. Rosales-Ruiz, Kathleen Strickland and Kathryn Schooley) determined that the children who were 5 years of age in that particular study

were generally able to move from Step 4 to Step 5 without additional training. Most of the children who were 4 years old needed additional training. Because the ability to mediate is a necessary prerequisite to move through this procedure without error, this method needs to be further assessed with adjustments made for younger populations. When these children were trained to say the name of the picture in the presence of the corresponding initial sounds, each participant acquired the required intraverbal chain over 2 to 3 sessions, and was able to complete the series of stimulus shaping steps successfully. 1 major prerequisite for this program, as well as in learning to read, is verbal imitation. The learner should be able to accurately imitate the sound emitted by the teacher. For example, if the teacher says the letter sound for b, the child should say the sound for b accurately and not the sound for v. Verbal imitation should be taught initially, if necessary before beginning either the errorless or errorful procedures. Arguably, acquiring the ability to mediate is a requirement not only for accurate responding in this stimulus shaping procedure but also for learning to read.

One important consideration in evaluating the results of this study was the need to reduce the number of targets in the errorful procedure for 3 of the 4 participants. The comparison between teaching methods may have been more informative if equal targets were being taught simultaneously. Regardless, even when reducing targets for the errorful procedure participants still made many errors and 2 of the 4 never acquired all 6 target letters. In contrast all participants acquired the 6 target letter sounds in less time and with fewer errors in the errorless procedure. Ethical considerations, such as poor performance and high rates of errors contributed to the decision to reduce the

number of targets in the errorful condition. This decision was also supported in the literature (Binder, 1996).

Results of the 30-day retention test (which examined only responses made in the hear/point learning channel for the errorless condition and examined only responses made in the see/say learning channel for the errorful condition) indicated that the errorful procedure generated better overall retention when compared to the errorless stimulus shaping procedure. Under the errorless condition CJR was the only participant tested who demonstrated 100% accuracy across 6 target letter sounds in both the post and retention tests. Participant CTS responded accurately for 2 target letter sounds in both the post and retention tests, and participant CEN responded accurately to 2 target letter sounds in the retention test but these were not the same 2 letters which were correctly identified in the post-test. Results generated under the errorful condition demonstrated almost perfect retention for participants CJR and CTS. Retention was observed only for the letter v with participant CEN. Perhaps failures in retention were due to the lack of response fluency. Although, not fully implemented under the present investigation, work in the area of precision teaching routinely tests for retention, endurance, application, and performance when determining if a skill is fluent and, thus, mastered (Binder, 1996; Fabrizio, 2003). Only 1 of the 4 participants, CJM, met the fluency aim of 60/min across all 6 target letter sounds. The remaining 3 ranged from 20-40 responses/min. However, retention and generalization were still observed in 2 of the 3 participants tested in both follow up tests. By comparison, performance under the errorless procedure generated variable rates across both sessions and participants. The highest rate was 16/min and was achieved by only 2 of the 4 participants on the last day

of teaching. Instructions provided after each response, such as “Point to a” for example definitely influenced overall rate and should be considered in future investigations when comparing rate of performance for errorless and errorful procedures.

Results of the generalization test across the hear/point, see/say, and see/point/say learning channels were similar to those generated during the retention test for each of the 3 participants. Overall performance for 2 of 3 participants tested suggests that the errorful procedure used in this study results in performance that readily generalizes across learning channels, and the errorless procedure does not. Under the errorless condition CJR and CEN did not accurately identify any letter in the see/say or see/point/say tests. Participant CTS was able to identify only the letter t in the see/say but not the see/point/say. Under the errorful condition, participant CJR accurately identified 5 letters in the see/say learning channel and 4 letters in the see/point/say learning channel. Participant CTS accurately identified 4 letters in the see/say learning channel and 5 letters in the see/point/say learning channel. Participant, CEN accurately identified only letter v in both the see/say and see/point/say learning channels. An additional finding was that letters which were shown to generalize at the post-test were also retained at the 30-day retention test, suggesting that retention and generalization are related. Binder (1996) refers to an earlier paper written by Lindsley in 1992 which cites evidence “indicating that learning and performance in 1 channel are generally independent of (or cannot be predicted from) others, recommending explicit assessment and instruction in every channel of interest in a given curriculum area” (Binder, p. 181).

Studies of errorless discrimination learning have focused primarily on acquisition of the discrimination, paying little attention to the issue of retention or generalization. This leads to a major implication of these findings: although acquisition of difficult letter sound discriminations can be achieved with very few errors and in a relatively short time when taught using an errorless procedure; generalization training must be specifically programmed into the procedure before relying on these methods alone. In contrast, fluency-based instruction used only to teach acquisition of novel stimuli produced overall better retention and generalization when compared to the errorless technique. Perhaps, by empirically examining components of fluency based instruction methods and in isolation, procedures may be derived which will improve upon the errorless procedures. 1 consideration could be to examine teaching acquisition of the novel skill using the errorless stimulus shaping procedure with an additional fluency aim determined by prior research. In the present investigation, as stated previously, rate of responding was significantly lower (i.e., 20-40/min under the errorful vs. 6-16/min under errorless). Although rate under the errorful method did not meet empirically generated fluency aims (e.g., 60-80/min), generalization and retention was readily generated. However, at the present time, it remains unclear as to how rate of responding or number of practice opportunities/stimulus presentations is related to retention and generalization. Based on this report alone, it is clear that many more stimulus presentations were required for both acquisition and increased rate under the errorful procedure. Using the errorless stimulus shaping method to teach acquisition first and then setting goals for faster responding may help answer that question.

Results of individual preference demonstrated that 3 of the 4 participants preferred (i.e., selected to do first when presented with a choice of both teaching methods) the errorless procedure. These 3 participants had also failed to acquire all 6 target letter sounds under the errorful procedure. Participant, CJM was the only participant who selected the errorful procedure more often (i.e., 66% of sessions) and also was the only participant to acquire all 6 target letters in the same number of sessions as in the errorless procedure. Previous work supports this finding: children may prefer the method which provides the greatest density of reinforcement and which results in faster acquisition and fewer errors (Griffiths et al., 1976; Keel et al., 1997). Keel et al (1997) assessed preference and determined that each child preferred the method with which they learned best and had the fewest observable signs of frustration. Griffiths and Griffiths (1976) also assessed preference and concluded that children preferred their errorless fading procedure to a trial-and-error procedure because the errorless fading procedure supplied a greater density of reinforcement.

Another important consideration in the evaluation of this study is the observed variability across participant's performance, which became evident only during the teaching sessions. Baseline performance was relatively equal across participants where pretests of the 12 target letter sounds determined that all 4 participants had not acquired any of the target letter sounds. Although, participants accurately identified 2 to 5 correct letters in the hear/point learning channel, they were unable to vocalize the letter sound when required to do so in the remaining 2 learning channels. These results suggested that performance in the hear/point learning channel may have been due to chance since each participant had a 1 in 6 chance of accurately pointing to the correct

letter. Examining individual performance during teaching sessions revealed that only CJM learned each set of target letters quickly with relatively few errors across both the errorless and errorful methods. The remaining 3 participants demonstrated individual differences. Participant CJR was the only 1 of the remaining 3 who acquired all 12 letter sound discriminations. Participant CTS acquired 2 target letters in the errorless and all 6 in the errorful teaching methods, while participant CEN mastered only the letter V taught in the errorful teaching method. Perhaps, with more than 3 to 4 weeks of training, these participants may have acquired all 12 target sounds and demonstrated both retention and generalization. It is also possible that another teaching method may have been necessary, especially for CEN who demonstrated acquisition of only 1 target letter sound. These results are consistent with those cited in Keel et al. (1997) who found no single method effective for all children when comparing errorless procedures such as stimulus shaping, stimulus fading, and time delay to trial and error. Although this could be a potential limitation, methods of assessing prerequisite skills necessary to excel with each method could aid in planning and implementing the appropriate method for each individual learner. For instance, participant CEN was not readily able to sit at a table and attend continuously for more than a few minutes. Any method employed would first have to reinforce attending for longer and longer periods of time before successfully beginning this program. Frequent breaks and a higher density of reinforcement may also have facilitated this child's success.

## Conclusion

When the issue is which method is more efficient at teaching difficult letter sound



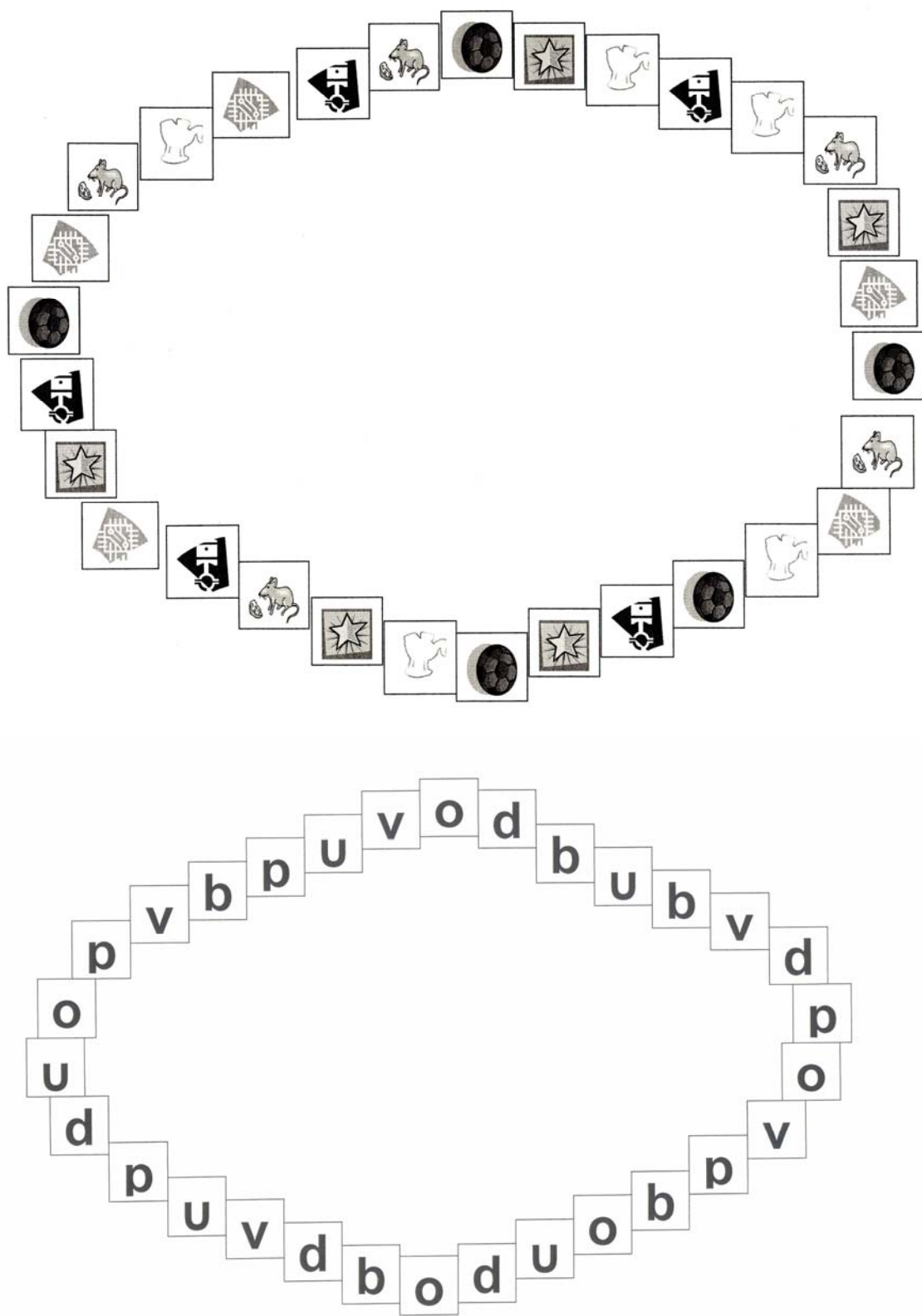
discriminations, stimulus shaping was more successful at teaching all 6 target letter sounds across all 4 participants. The success of this procedure is thought to be because each of the target pictures were different from 1 another and thus easily discriminated and second because the shape of the initial stimulus resembled the stimulus in the terminal discrimination (i.e., criterion-related stimuli). Lastly, each progressive change in the stimulus was small enough to facilitate accurate responding. Although, this method resulted in responding which was 100% accurate for each of the 4 participants on the final session of the errorless procedure; it was not maintained even 2 days following the final session (i.e., over the weekend) for 2 of the 3 participants who were tested. Future research in errorless discrimination training could program the stimuli to be presented under varying conditions (i.e., different learning channels), which would make training for generalization inherent in the procedure. Second, extending the final session over a period of days (i.e., expose participants to the terminal stimuli multiple times under those conditions before testing for retention and generalization) may also improve responding in follow up probes.

“The correct principles of teaching difficult discriminations...often go against the grain of common sense (Gilbert, 1978, p. 279).” Traditional methods typically teach the easy material first and then gradually add onto what has been assumed to have been acquired getting progressively more complex. Stimuli which are thought to be similar and thus difficult to discriminate are taught separately, which is also thought to facilitate acquisition. The current investigation demonstrated that 6 novel stimuli could be taught simultaneously, efficiently, and with few errors by doing the exact opposite of traditional methods. Although further modifications aimed at improving rates of retention and

generalization are necessary, the research is clear that an errorless approach is 1 component to improved classroom instruction.



*Fig. 1.* Sample pre-training stimuli.



*Fig. 2.* Top: Pre-training see/point/say configuration. Bottom: Pre, post and retention test see/point/say configuration.

<b>p</b>	<b>d</b>	<b>b</b>
<b>o</b>	<b>u</b>	<b>v</b>

<b>f</b>	<b>s</b>	<b>t</b>
<b>e</b>	<b>a</b>	<b>i</b>

*Fig. 3.* Errorful training stimuli. Top chart: Letter Set 1; bottom chart: Letter Set 2.



*Fig. 4.* Errorless training stimuli. Reading left to right; top 6 pictures correspond to letters **u p b v o d**; bottom 6 pictures correspond to letters **s e l a t f**.

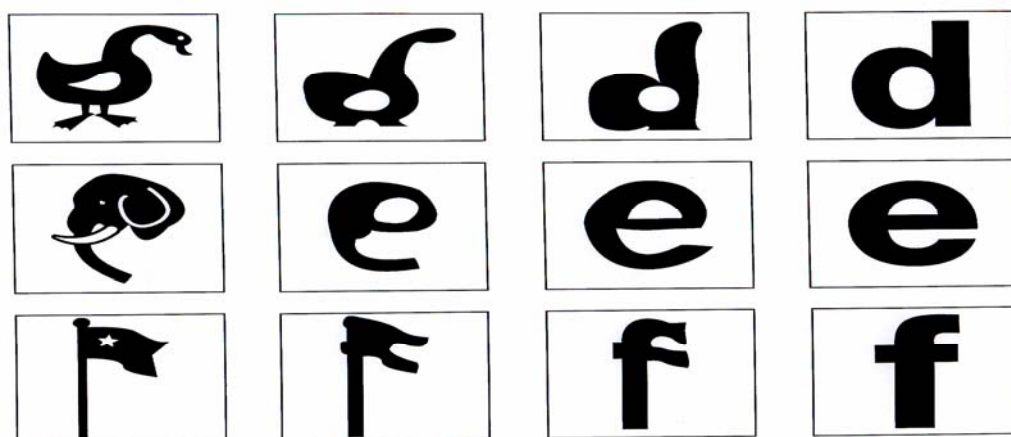
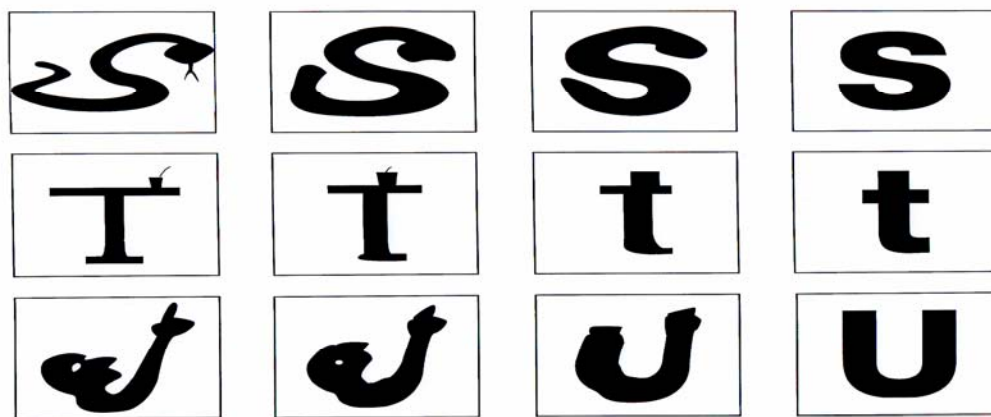


Fig. 5. Sample sequence of training steps for errorless procedure.



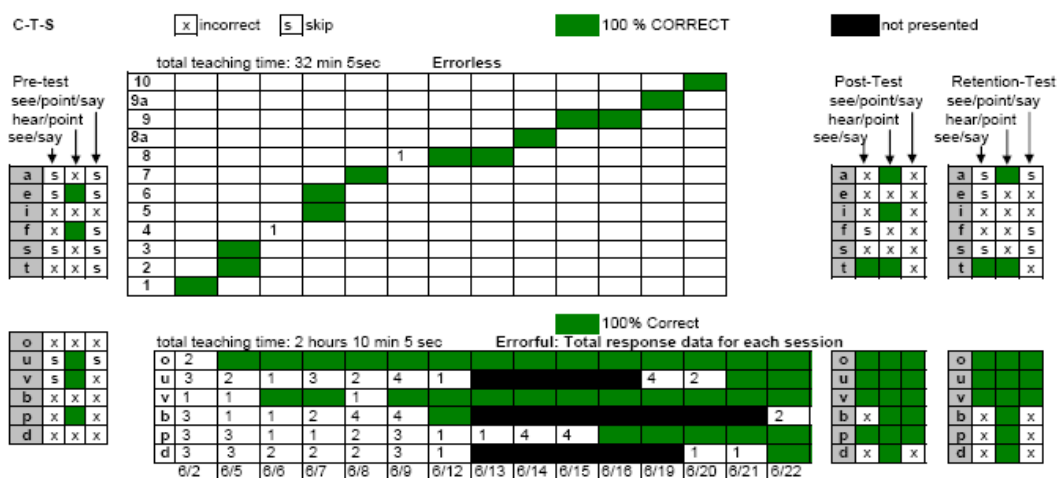


Fig. 8. Participant CTS summary data.

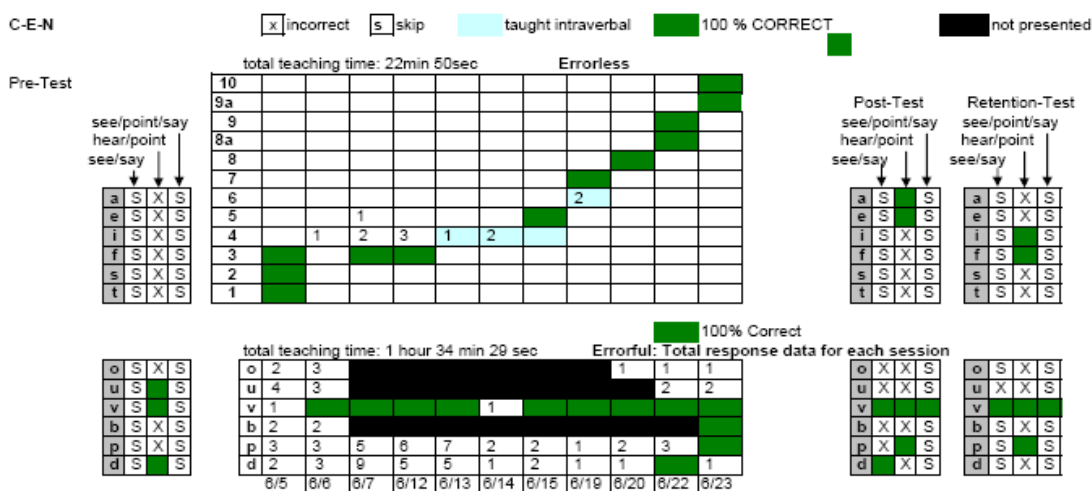
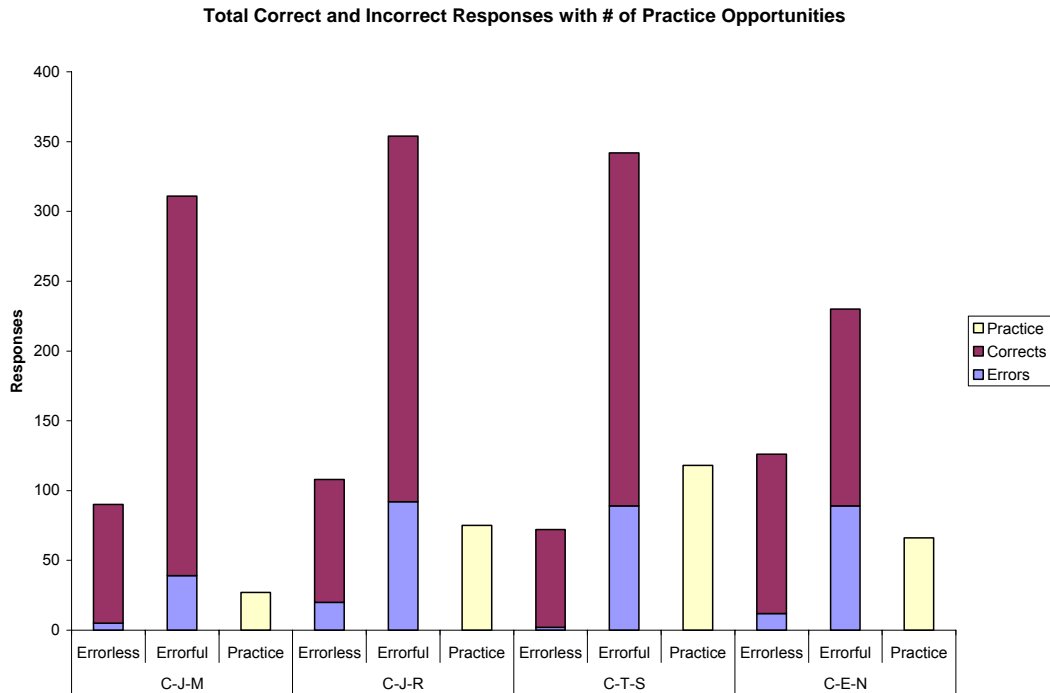
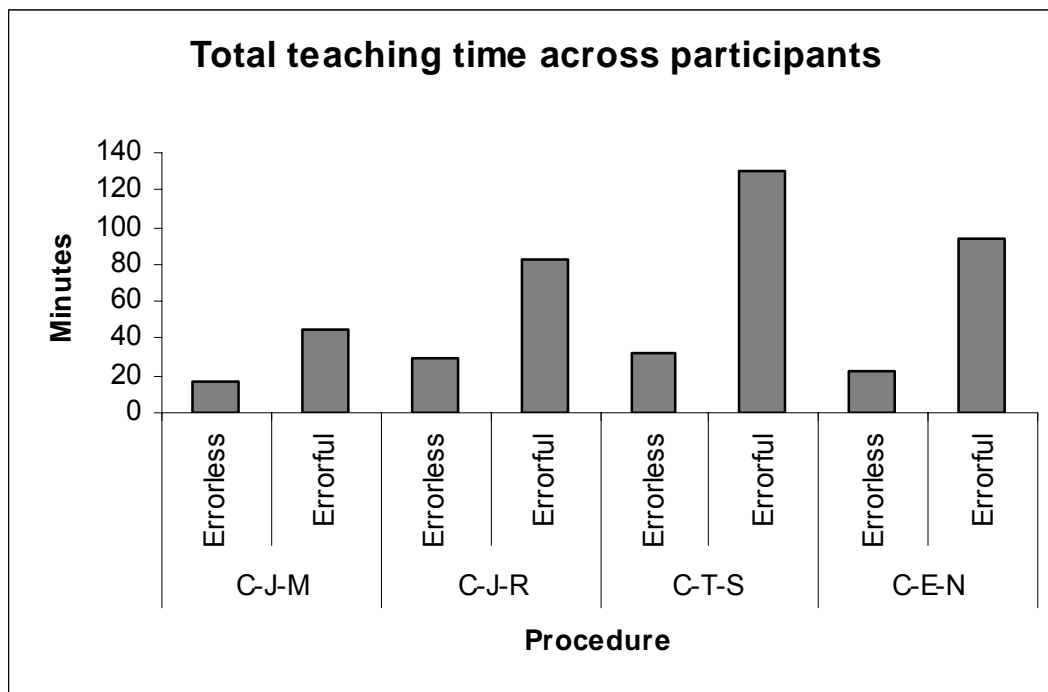


Fig. 9. Participant CEN summary data.





*Fig. 10.* Total correct and incorrect responses across both errorless and errorful teaching methods for participants CJM, CJR, CTS and CEN. Total practice opportunities illustrate total number of flash card presentations occurring before and between timings in the errorful teaching method.



*Fig. 11.* Total teaching time across both errorless and errorful teaching methods for participants CJM, CJR, CTS, and CEN.

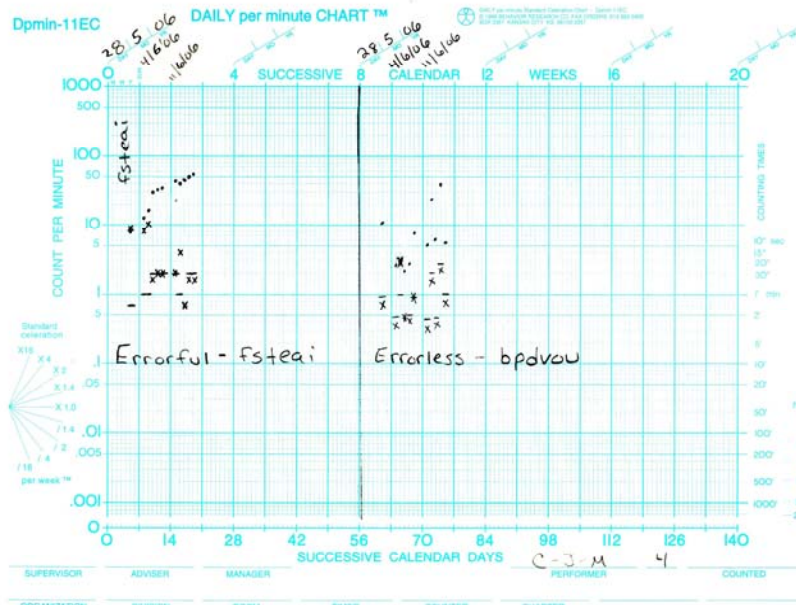


Fig. 12. Participant CJM. Correct and incorrect responses calculated as rate per minute across both errorful (left side of standard celeration chart) and errorless (right side of standard celeration chart) teaching methods. Charted data from each method are shown separately, instead of overlaid on each day, for easier interpretation.

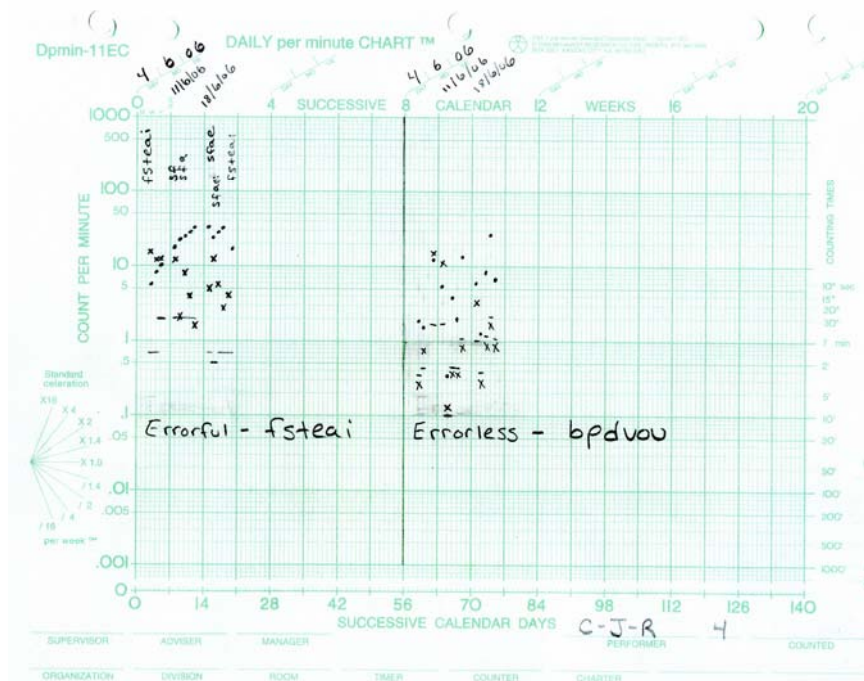


Fig. 13. Participant CJR. Correct and incorrect responses calculated as rate per minute across both errorful (left side of standard celeration chart) and errorless (right side of standard celeration chart) teaching methods. Charted data from each method are shown separately, instead of overlaid on each day, for easier interpretation.

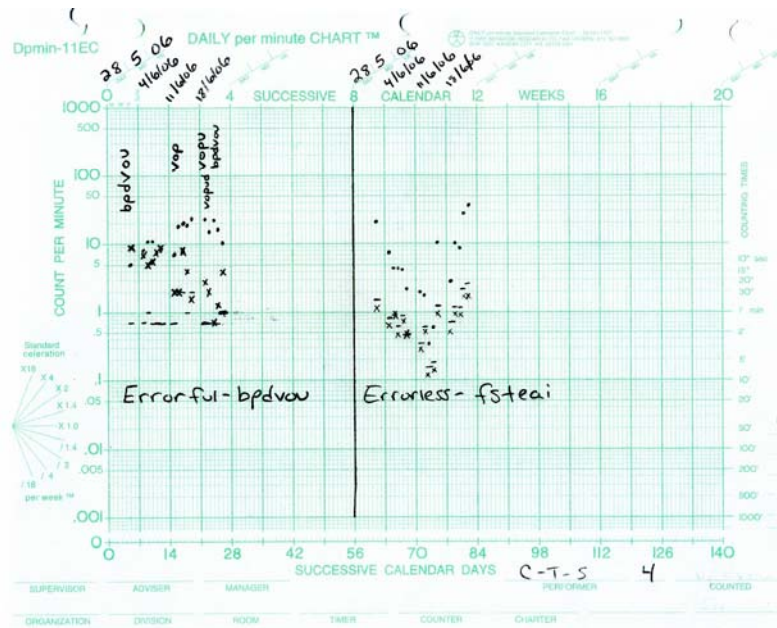


Fig. 14. Participant CTS. Correct and incorrect responses calculated as rate per minute across both errorful (left side of standard celeration chart) and errorless (right side of standard celeration chart) teaching methods. Charted data from each method are shown separately, instead of overlaid on each day, for easier interpretation.

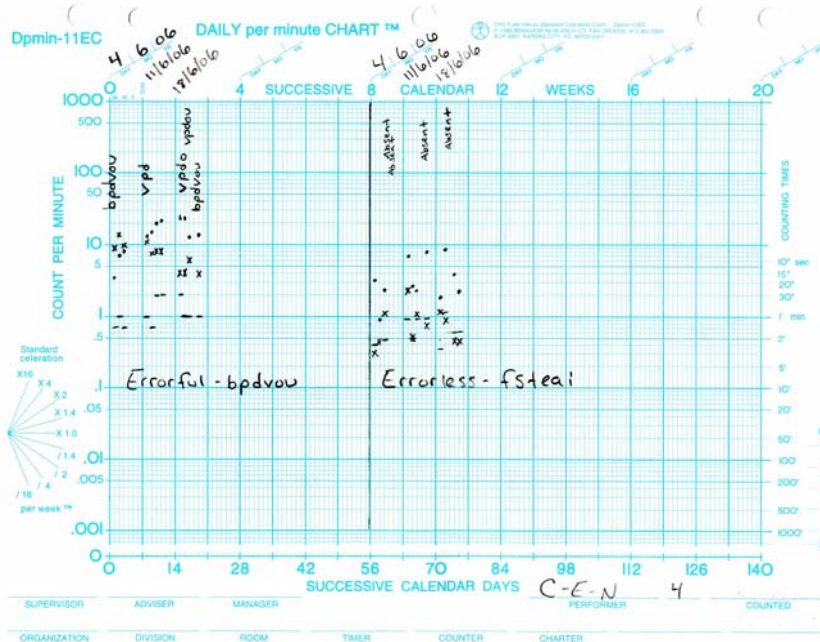


Fig. 15. Participant CEN. Correct and incorrect responses calculated as rate per minute across both errorful (left side of standard celeration chart) and errorless (right side of standard celeration chart) teaching methods. Charted data from each method are shown separately, instead of overlaid on each day, for easier interpretation.

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